No. XXVI.

Description and Use of a very simple Instrument for setting up Sun-Dials, and for many other useful Purposes. By Robert Patterson.—Read, October 17, 1817.

HAVING occasion, some time ago, to set up a sun-dial, for a friend in the country, a method of doing this occurred to me, which, from its great simplicity, as well as accuracy, and the variety of other useful purposes for which it may be employed, I flatter myself, the Society will not think unworthy of their notice.

Description of the Instrument made use of for the above purpose.

This instrument, in its most simple form, consists of

1. A square prism or block of wood, about three inches long, and 1 1-2 on the side.

2. A wooden scale or index, about 8 inches long, 1 1-2 broad, and 1-4 thick. Along the flat sides of this scale, there are drawn, by a carpenter's gauge, three or four fine lines, parallel to the opposite edges of the scale. Near one end of this scale, there is inserted a brass pin or piece of wire, projecting about 1 or 2 inches perpendicularly above the surface;

and near the opposite end there is erected a strip of pasteboard, or the like, with a straight black line, drawn on its inner surface, parallel to the pin or wire, and both terminating in the same gauge-line drawn along the surface of the index. Into the center of one side of the square block is firmly inserted a brass pin, projecting about half an inch perpendicularly above the surface, and terminating with a few threads of a screw. This pin passes through a hole in the center of the index, which, by means of a screw-nut, may be made fast in any position required.

Use of the above Instrument, with the aid of a common Semicircular Protractor, in setting up a Sun-Dial made for any plane, whether horizontal, vertical, or reclining.

1. Inverting the instrument, place the protractor on the lower side of the index, with its graduated side uppermost, and its straight edge in contact with the square block.

2. By moving the index, bring the center of the protractor, and the degree, &c. of the sun's present declination, counted from 90° as 0, both exactly above the same gauge-line drawn on the index; observing, that when the declination is north, and the instrument to be used in the forenoon, or south, and to be used in the afternoon, then, the declination must be taken on the *right hand* of the 90°, and vice versa.

3. The dial being placed on its proper stand, or plane for which it was made, the sun shining, and, when circumstances will allow, not less than 45° of azimuth from the meridian, (but the nearer to due east or west the better) place the instrument with the square block in contact with that side of the gnomon of the dial next to the sun, and the index resting on its upper edge.

4. With one hand, depress the index, and with the other, gently move round the dial on its stand, till the shadow of the pin, inserted in the index, falls exactly on the black line drawn on the opposite piece of pasteboard. The dial is then truly

placed; and, in this position, after repeated trials, by way of verification, may be permanently fixed.

The rationale of the above process, as well as of what follows, will, it is presumed, be sufficiently obvious, without any explanatory figure, or additional elucidation.

The above instrument, with a little variation, and additional apparatus, may be employed with considerable accuracy in the practical solution of many other useful problems, as will now be explained.

Variation in the Instrument.

Instead of the pin, &c. in the index, let there be attached to its opposite ends a pair of sight-vanes, nearly such as in the common surveying instruments. One of these, however, may have a narrow slit of about 1-20th of an inch, and the other a wider one of about 1-8th of an inch, extending nearly their whole length. The index being about 8 inches long, the sight-vanes may be about 5 or 6 inches high. Also, let a saw-kerf, about 3-4ths of an inch deep, be cut along the lower side of the square block, opposite to that on which the index is attached, and parallel to the two opposite sides of the block.

Additional Apparatus.

This consists of

1. A simple Jacob-staff; being, merely, a circular board, or tablet, of about seven inches in diameter, with a large hole in the middle, and supported by three diverging legs.

2. A stand, with a universal gnomon, consisting of—(1.) A circular board of about seven inches in diameter, supported by three brass screws, which serve as feet, and, by means of a spirit-level, to make it horizontal. (2.) A square pillar,

erected on the center of this circular board, about 6 inches long, and 1 1-2 on the side. A brass pin, terminating with a few threads of screw, is firmly inserted into the lower end of this pillar, which passes through a hole in the center of the board: and thus, by means of a screw-nut, below the board, the pillar may be fixed in any position required. The top of this pillar is slit down, by a saw, about 5 inches, the kerf being parallel to two opposite sides of the square pillar. This kerf is made to receive (3.) A universal gnomon, being an oblong rectangular piece of sheet or cast brass, about 7 1-2 inches long, and 4 broad; having a brass pin passing through its center, and the upper end of the pillar, with a couple of nut-screws on the opposite ends, by which to make it fast in any position required. Along the sides of this gnomon, there are to be drawn three or four fine gauge-lines, parallel to the opposite edges, as directed with respect to the index.

Problems which may be practically solved, with considerable accuracy, by the above Apparatus.

PROBLEM I.

To find the angular altitude or depression of any visible object.

Solution 1. On the tablet of the Jacob-staff, set the stand, with its feet in three deep holes, made to receive them, to prevent sliding.

2. By means of the spirit-level, bring the upper surface of the circular board of the stand, and also the upper edge of the gnomon, into a true horizontal position.

3. Slip the kerf of the index-block on one of the vertical ends of the gnomon, where, by its friction, it will be prevented from moving.

4. Elevate, or depress, the index, and move round the pillar of the stand, till the eye, placed at the narrow slit of one of the sight-vanes, shall see the object through the slit in the opposite vane. If the sun be the object, the eye may be defended by a coloured shade, or piece of smoked glass; or, the lucid line passing through the broader slit may be made to fall upon the narrower slit in the opposite sight-vane.

5. Remove the index from the gnomon, and then, by the protractor, you may measure the angle which the index makes with its square block, which will be the altitude, or depression, or complement thereof, according as the angle is measured from the end, or from the side of the square block.

PROBLEM II.

To draw a true meridian line, on any plane level surface.

Solution. 1. Place the protractor with its straight edge close against one side of the upright pillar, and elevate the gnomon till the center of the protractor, and the degree, &c. of the latitude of the place, reckoned from 90° considered as 0, both fall exactly above the same gauge-line, drawn along the side of the gnomon.

2. By means of the protractor, set the index to the sun's declination, as directed in setting up a dial.

3. Set the stand on the surface where the meridian line is to be drawn, and, by means of the screws and spirit-level, bring the circular board to a true horizontal position.

4. The sun shining, and not too near the meridian, proceed as directed in setting up a dial; turning round the upright pillar, till the lucid line, from the broader slit, falls upon, and is bisected by the narrower slit, as in the last problem. The gnomon and the two sides of the square pillar parallel thereto, will now coincide with the meridian of the place; and then, by means of a straight edge, placed in contact with one of the meridian sides of the square pillar, the meridian line may be transferred to the given surface.

PROBLEM III.

To find the azimuth or bearing of any visible object.

Solution. 1. Place the stand on the tablet of the Jacob-staff, and then proceed, in every respect, as directed in drawing a meridian line; only, that in this case, you may look directly at the sun, as directed in finding his altitude, in Prob. I.

2. Depress the elevated end of the gnomon, till its upper edge appears, by the spirit-level, to be horizontal.

3. Slip the kerf of the index-block on the upper edge of the gnomon, and, your eye being placed at the narrow slit eye-vane, turn round the index till you see the object through the broader slit of the opposite vane.

4. Remove the index, and then, by the protractor, you may measure the azimuth, as directed in Problem I. in measuring an altitude.

PROBLEM IV.

To find the hour of the day.

Solution. 1. Proceed, in every respect, as directed in Prob. III. art. 1.

2. Slip the kerf of the index-block on the elevated end of the gnomon; and, if the sun shines bright, turn round the index with the broader slit vane towards the sun, till the broad lucid line is bisected by the narrow slit in the opposite vane. Or, if the sun be obscure, you may place your eye at the narrow slit, (defended by a coloured shade, &c. if necessary) and looking directly at the sun, turn round the index, till it appears opposite the center of the broader slit.

3. Remove the index, and you may then, by the protractor, measure the hour-angle from the meridian, as directed in measuring an altitude or azimuth. If the index be previously set to some whole degree in advance, then, by waiting till the sun appears opposite to the middle of the slit,

you may ascertain the time with great accuracy. Or, if you take a mean of the times per watch, corresponding to the four contacts of the limbs with the sides of the slit, you may ascertain the error of watch, generally within less than a minute.

NOTE I. It is easy to conceive, how the reverses of some of the foregoing problems may be solved. For instance,

1. The meridian and latitude of the place being given—to find the time, declination, and azimuth of the sun.

2. The meridian and declination being given—to find the latitude, time, and azimuth.

3. The latitude and time being given—to find the meridian, declination, and azimuth; and this at any time of the day. &c. &c. &c.

NOTE II. Having the declination of the moon, or of any other planet, or fixed star, together with the latitude of the place, it is obvious that the meridian may be found by these as well as by the sun. And if their right ascensions be given, together with that of the sun, then, you may also find the hour of the night.

NOTE III. It will readily occur how the above instrument may be employed to find the variation of the magnetic needle.

NOTE IV. Though the error in the solution of the above problems, arising from the refraction of the sun, &c. may generally be neglected, as very small; yet *this*, when thought necessary, may be readily allowed for, as follows:—

1. Ascertain, by means of the spirit-level and protractor, &c. the *value*, in altitude, of some one of the screws of the circular stand; i. e. how many revolutions and parts correspond to the change of a degree in altitude.

2. Place *this* screw directly towards the sun, &c.; then after levelling, and previously to making the observation, turn *forward* the screw so much as the refraction corresponding to the estimated altitude requires.